

The DARWIN Workspace Environment for Analysing Experimental and Computational Data

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Abstract

This article describes the DARWIN Workspace Environment and software components developed at NASA Ames to remotely analyze experimental and computational data for aeronautics tests.

INTRODUCTION

NASA Ames Research Center is using information systems technology to redefine the aeronautics wind-tunnel and computational testing. The project, called DARWIN,¹ enables wind tunnel and numerical test results to be produced and made available to industry and universities faster and cheaper. This paper will provide the latest details of DARWIN Workspace Environment⁴ developments, the incorporation of rule-based assistants, and the integration with on-line cooperative numerical simulations.

The framework for the DARWIN Workspace Environment is an web browser that operates over the internal NASA AEROnet and NREN (NASA Research Network) communications network. Specialized data analysis and visualization tools are integrated with the browser to enable users to make detailed interpretations of test data. For those situations where numerical simulations could help with the analysis of test data, an intelligent software assistant is employed to help test engineers launch a computational fluid dynamics (CFD) solver program using the actual wind-tunnel conditions. When a solution is generated, the feature-recognition component of the assistant can automatically identify and display a variety of flow features, such as shocks and vortices, which can then be compared with wind tunnel results

The goal of the DARWIN system is to provide the foundation to achieve design cycle iteration (design - test - redesign) within a single entry to a test facility. This capability requires complete and efficient access to all relevant design cycle information and systems. This includes test model design and geometry, CFD solutions and grids, and wind tunnel and instrumentation data. The system needs to ultimately access rapid prototyping facilities to enable the rapid construction of new test models. These new models would be tested within current the wind tunnel test entry. The DARWIN system is designed to provide the aeronautical researcher or designer with access to enough relevant information and knowledge in real-time to allow for responsive and informed design decisions.

DARWIN WORKSPACE ENVIRONMENT

The DARWIN Workspace environment is composed of a Web browser that can display HTML and Java "pages," the DARWIN executive software, and a collection of software applications for performing specialized data analysis, visualization, and collaboration tasks. The browser, the DARWIN executive, and the tool kit applications are all resident on the customer's workstation. The HTML pages, which can be static documents or the dynamic results of server scripts or client JavaScript functions, are retrieved from the DARWIN server via secure network protocols.

To access data from a particular wind tunnel test, a DARWIN user enters the system by requesting the a secure web access from the DARWIN server and then entering a user name and password. The IP address of the requesting computer is checked against a list of allowed machines before access is granted. Once logged in to the DARWIN system, the user is presented with links to the tests that he is permitted to

review. The web site for wind tunnel test typically contains a summary of the test's purpose, statement of progress, and various views on the data collected so far.

All of the wind tunnel test data and the computational results data is stored in the DARWIN database. The DARWIN database is composed of two parts: (1) the formal database, which contains meta-data sufficient for logical queries and for locating raw data files in (2) the file system, which contains the top level results used for data analysis and design cycle decisions made by the aerodynamicists.³ The DARWIN web server accesses the database to retrieve the latest wind tunnel data and build up-to-date displays for the user. Dynamic plots of the data are generated using a graph package written in Java. The user may also customize the display of data by using a form-based interface to specify preferences for what

plots should be generated and what columns should appear in the summary tables.

The DARWIN Workspace Environment can directly display or plot most of the raw data files in the DARWIN database file system. However, for in-depth analysis, more complex manipulation of the files is required for evaluating and interpreting the data. Several specialized software programs are bundled with the DARWIN Workspace environment to aid in analysis of particular types of data files.

A simple server-side rule-based controls the test and data analysis options and a client-side rule-based controls the user specific setups desired for the Workspace. Each of these is parsed by the DARWIN executive. The DARWIN executive software also provides the communication link between the web browser and the specialized data analysis tools. The executive software is written in PERL, Java, and

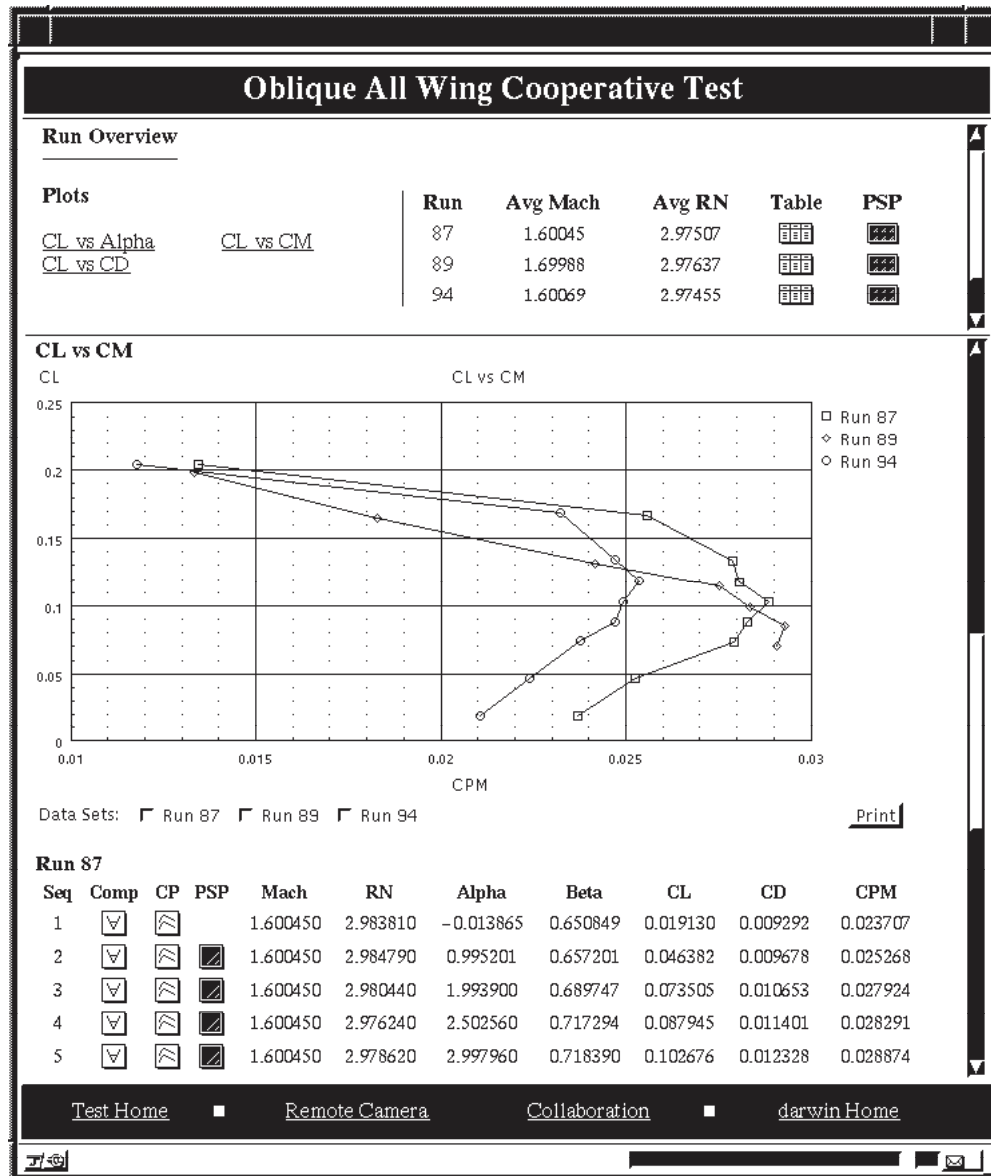


Figure 1. DARWIN Workspace Environment Display of Wind Tunnel Data

JavaScript embedded in HTML. These cross-platform interpretive languages are easily understood and provide a simple way to distribute a cross-platform graphical interface tool built upon an web browser. The executive's role is to coordinate the browser-related applications and the additional visualization and collaboration tools as determined from the user and test specific options. The executive sends signals to the browser telling what information pages it should be displaying and coordinates the signals sent to the server-side and the client collaboration tools..

CFD ASSISTANT

For wind tunnel experimentalists, a system for initiating new computational runs, reviewing existing numerical solutions, and comparing them to tunnel data is highly desirable. Typically CFD simulations are done well in advance of commencing testing in the wind tunnel. The results if available will be in the DARWIN system for comparison. However, if no comparable numerical results exist, the test engineer

or designer may use the CFD Assistant to help with configuring a CFD flow solver to produce a new simulation and with identifying flow features of the resulting solution file. A prototypical CFD assistant has been developed that leads the engineer through the setup of a flow solver and provides advice on configuring it correctly for a valid solution.

Two keys to producing a successful CFD solution are properly configuring the input files and understanding the domain of applicability of the solver code. The solver assistant checks the wind tunnel conditions proposed for the simulation and informs the user of whether the solver code is capable of producing a physically valid solution for the given situation. If the code is appropriate, then the necessary input files are generated and configured automatically so that the engineer does not have to bother with details of file formatting and naming conventions required by the solver. The solver assistant will allow users to setup and launch flow solver codes via the DARWIN Worspace

Netscape: Submit Problem

File Edit View Go Bookmarks Options Directory Window Help

Back Forward Home Reload Load Images Open... Print... Find... Stop

Netsite: http://siren.stanford.edu/cgi-bin/solver_input.cgi

Grid File: Settings:

Flow Parameters Alpha: <input type="text" value="40.0"/> Mach: <input type="text" value="0.3"/> Reynold's number: <input type="text" value="200000000"/> Prandtl number: <input type="text" value="0.7"/> Freestream temperature: <input type="text" value="520.0"/> Gamma: <input type="text" value="1.4"/>	Time Time step: <input type="text" value="0.01"/> <input checked="" type="checkbox"/> Explicit <input checked="" type="checkbox"/> 1st order accurate in time <input checked="" type="checkbox"/> Trapezoidal order accurate in time
Viscosity <input checked="" type="checkbox"/> Viscous <input type="checkbox"/> Inviscid	Restart <input checked="" type="checkbox"/> Netscape: Error
Smoothing Explicit: <input type="text" value="0.03"/> Implicit: <input type="text" value="0.03"/> Boundary layer reduction: <input type="text" value="1.0"/>	Boundary Conditions Periodic: <input type="checkbox"/> Trailing edge: <input type="text" value="0"/> Trailing edge upper: <input type="text" value="0"/> FAIRF: <input checked="" type="checkbox"/> True <input type="checkbox"/> False FIAX: <input type="checkbox"/> True <input checked="" type="checkbox"/> False

Submit Check Settings Save Settings

JavaScript Alert:
The following errors were found:
-- Reynold's number must be >= 1.0 and <= 1E7.
OK

Environment. Fluid dynamicists could also use this system to launch codes and track the solutions, as well as have access to experimental data for analysis and review.

The CFD assistant's goal is to intercept as many errors as possible before spending computer time on the flow solver. The input advisor is being developed at Ames and has a parameter dependency rulebase. The values of some input parameters are constrained by the values of other parameters. The prototype contains a knowledge base of rules on parameter dependencies and warns the user when these constraints are violated. This feature reduces the incidence of namelists containing contradictory options.

The software incorporates knowledge of the limitations of various turbulence models so that it may warn the user of the likelihood of poor outcomes. Given a description of the flow field (Mach number, angle of attack, etc.), the program will evaluate the applicability of the selected turbulence model. It will also recommend the best turbulence model for the situation, if requested. This feature improves the quality of the flow solution by insuring that the most appropriate turbulence model is utilized

Once the solver has produced a solution, the test engineer can use the CFD Assistant's feature extractor component to check for expected flow features such as shocks or vortices. Algorithms for detecting these features are captured by the program so the test engineer does not need to know the details of how a CFD expert would go about detecting these features. The feature extraction component also incorporates a data visualization module that displays the features overlaid on the model grid.



Figure 3. Feature Extractor Displaying Shock and Vortex Core Over a Wing

SUMMARY

The DARWIN Workspace Environment is designed to provide the aerospace customer of the future with the necessary information access to greatly improve the design cycle process by gleaning more knowledge from available data and thus providing the capability to perform true design cycle iterations in a single test entry.

The prototype CFD Assistant gives test engineers the capability to produce numeric simulations of wind tunnel runs while the wind tunnel test is still in progress. Any insights gained by comparing tunnel data with computational models can thus be applied to improving and fine-tuning further collection of data during the test.

A larger program at Ames, called the Aeronautics Design Test Environment⁵ (ADTE) is using and supporting extension of the DARWIN system. ADTE has created a subproject, Facility Environment Simulation Tools (FEST) that will greatly extend the capability of the CFD Assistant prototype. The DARWIN Workspace Environment will present the results of that system to the remote aeronautics community.

The DARWIN Workspace Environment will also be extended in 1997 to support experimental tests and computational data from spacecraft re-entry body aerothermophysics.

References

1. Koga, D. J., Korsmeyer, D. J., and Schreiner, J. A., "DARWIN Information System of NASA—An Introduction," AIAA-96-2249, 19th AIAA Advanced Measurement and Ground Testing Technology Conference, June 17–20, 1996, New Orleans, LA.
2. Korsmeyer, D. J., Walton, J. D., Gilbaugh, B. L., DARWIN—Remote Access and Intelligent Data Visualization Elements, AIAA-96-2250, AIAA 19th Advanced Measurement and Ground Testing Technology Conference, June 17–20, 1996, New Orleans, LA.
3. Schreiner, J. A., Trosin, P. J., Pochel, C. A., and Koga, D. J., "DARWIN—Integrated Instrumentation and Intelligent Database Elements," AIAA-96-2251, 19th AIAA Advanced Measurement and Ground Testing Technology Conference, June 17–20, 1996, New Orleans, LA.
4. Walton, J. D., Korsmeyer, D. J., Batra, R. K., and Levy, Y., "The DARWIN Workspace Environment

for Remote Access to Aeronautics Data,” AIAA-97-0667, 35th Aerospace Sciences Meeting, January 6-10, 1997, Reno, NV.

5. George, M., “The Aeronautics Design Test Environment,” NASA Ames Proposal, available at <http://www.darwin.arc.nasa.gov/darwinweb/ADTEProposal3.html>